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NEW DAIRY PRODUCTS For Use In Candy Manufacture

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Milk has been used as a basic ingredient in confections for many years and contributes unique functional attributes to the flavor, texture and body of these products (Kinsella, 1970). Recent shortages of nonfat dry milk coupled with unstable sucrose prices have generated a search for other cheaper ingredients to substitute for these two materials without loss of product quality. Consequently, there has been renewed interest in cheese whey as a possible substitute in certain candy formulations.

Because whey contains only 7% total solids, fluid whey cannot be readily used for candy manufacture. However, with the development of economical processing innovations, high quality whey solids have become available for use in a variety of foods. The composition of the solids of two major whey types is shown in Table 1.

Milk sugar or lactose is the principal component of whey and has several unique properties. First of these is the solubility which differs from sucrose. As shown in Table 2, maximum lactose solubility is only 18% compared to 68% for sucrose. Webb (1950, 1966) has described how the insolubility of lactose in whey may be used to form a microcrystalline structure in fudge and has developed formulas for whey candies which take advantage of this property.

Table 1. Composition of Whey Solids

	Cheddar[a] cheese whey (sweet)	Cottage[b] cheese whey (acid)
% Total Protein	11.5	11.4
% Lactose	74.4	66.8
% Ash	7.4	10.2
% Lactic Acid	<1.0	9.6
% Fat	2.7	<1.0
pH	6.5	4.7

[a]Cerbulis, et al. (1972).
[b]Holsinger (unpublished data).

The forced crystallization procedure Webb describes includes the formation of small uniform-size crystals of lactose which serve to ensure shelf stability of the fudge.

Fluctuating sucrose prices have forced candy manufacturers to consider lactose as a filler for improved body and mouth feel of many confections and a possible source of sweetness. Lactose is not as sweet as sucrose, as shown by the relative sweetness values tabulated in Table 3. In general, about 3 times more lactose than sucrose is required to achieve the same sweetness level. As Tables 2 and 3 show, both glucose and galactose are sweeter and more soluble than lactose. It is important to note, however, that in solution, the sweetness of lactose improves, compared to sucrose, with increasing concentration. Unfortunately, the insolubility of lactose combined with its lack of sweetness limits its use as a sucrose substitute although it can serve to diminish the sweetness of overly sweet candy.

Table 2. Solubility of Sugars in Water at Room Temperature[a]

Sugar	Solubility - Percent
Sucrose	67.9
Glucose	45.4
Fructose	80.3
Galactose	40.6
Lactose	18.0

[a]International Critical Tables (1927).

Many new potential food uses would be opened up if the lactose in whey could be altered in some fashion to increase its sweetness and solubility. The human body metabolizes lactose after ingestion by action of the enzyme lactase. Lactose is attacked by lactase in the gut and hydrolyzed to its constituent monosaccharides glucose and galactose. Hydrolysis of lactose in whey by chemical or biological methods prior to further processing might serve to increase the sweetness of whey to the point where it could be utilized as a partial sucrose replacer in some formulated sweet foods.

Guy et al. (1974) have successfully prepared a variety of dairy products with 90% of the lactose present in hydrolyzed form by using lactase from nonhuman sources to hydrolyze the lactose prior to product manufacture. These products include 3:1 frozen concentrates, ice cream, and nonfat dry milk. The enzyme used in these studies was isolated from the yeast *Saccharomyces lactis* in the form of a colorless free-flowing powder by Gist-Brocade, Delft, The Netherlands and distributed in the United States by the Enzyme Development Corporation of New York City.

Table 3. Relative Sweetness of Sugars

Percent Concentration to Give Equivalent Sweetness				
Sucrose[a] %	Glucose[a] %	Fructose[a] %	Lactose[a] %	Galactose[b] %
1	1.8	0.8	3.5	2.1
5	8.3	4.2	15.7	8.3
10	13.9	8.6	25.9	15.0

[a]Webb, et al. (1974).
[b]Cameron (1947).

Organoleptic evaluation of fluid milks and reconstituted milk powders has shown that lactose hydrolysis caused a marked change in the intensity of sweet flavor. The judges considered noticeable sweetness of fluid milk to be a "foreign" flavor, and, as listed in Table 4, downgraded the product accordingly. No other off-flavors were identified.

Table 4. Dairy Products Laboratory Flavor Score Results From Lactase Treated Pasteurized Whole Milk[a] (ADSA score card used)

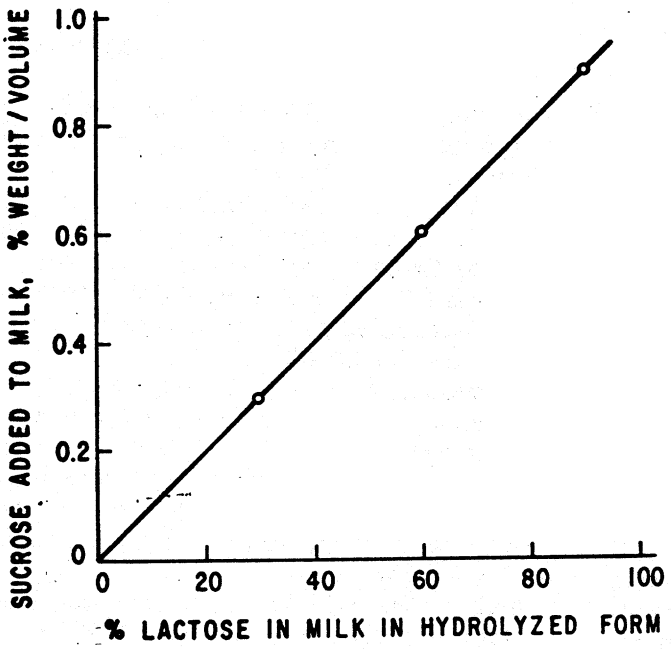
Sample	Flavor Score
Control	37.0
30% Lactose Hydrolyzed	37.0
60% Lactose Hydrolyzed	36.7
90% Lactose Hydrolyzed	36.2

[a]Guy et al. (1974).

Since milk products containing hydrolyzed lactose are characterized by sweetness, an objective sweetness scale was developed to simplify reporting organoleptic changes brought about by lactase treatment. The main feature of this system, shown in Figure 1, is the fact that the results of lactase action

can be equated with the increased sweetness associated with the addition of sucrose. Ninety per cent hydrolysis of lactose produces sweetness equivalent to approximately 0.9% added sucrose in pasteurized whole milk. That this result is not surprising may be seen from the data of Table 3. Glucose and galactose are each about half as sweet while lactose is only about one-fourth as sweet as sucrose. As milk contains approximately 4% lactose, 90% hydrolysis should increase the relative sweetness to that of a 1% sucrose solution.

Figure 1. Sucrose Equivalent of hydrolyzed lactose. (Holsinger and Guy, 1974).



The results of this study suggest that nonfat dry milk, an irreplaceable ingredient in many candies, may assume new and unique properties when used in confections if lactase-treated prior to drying.

Thompson and his associates (1974 a, b) have demonstrated that there may be economic advantages to manufacturing cheddar and cottage cheeses from lactase-treated milk. Only a small fraction of the sugars are used in the cheese-making process. Consequently, large quantities of cheddar and cottage wheys with 60-90% of their lactose in the hydrolyzed form may become available. To date, no one has successfully spray dried whey with 90% of its lactose in the hydrolyzed form. However, because the crystallization characteristics of such wheys are altered by lactose hydrolysis, noncrystallizing high solids syrups might be produced which should find a variety of uses in the food trade.

Candy manufacturers are well acquainted with sweetened condensed whey developed by Ramsdell and Webb (1938). This product contains about 38% whey solids, 38% sucrose, and 24% water. This product has been used as an ingredient in caramel manufacture for many years (Alikonis, 1972). Slow cooking of a caramel formulation containing whey develops more of the true caramel flavor and color because the high temperatures permit the Maillard or browning reaction to proceed. A lactase-treated whey, with 90% of its lactose in hydrolyzed form can be readily condensed to 70% total solids, 75% of which consists of glucose and galactose (Guy, 1974). This offers possibilities for use in caramel manufacture, not only because undesirable crystallization would be avoided, but the desirable caramel color and flavor would develop more rapidly and sucrose content might be reduced.

Although research utilizing this product in caramels and fudges is still underway, lactase-treated whey has been evaluated as an ingredient in ice cream (Guy, et al. 1974). Because of the increased sweetness brought about by lactose hydrolysis, sucrose levels could be reduced by 10% when lactase-treated whey was added at 25% of the total serum solids of the ice cream formulas. Decrease in caloric density due to the reduction in the quantity of the sucrose used did not alter acceptability of the ice cream.

Whey at the present time cannot be used in chocolate because it is not a permitted optional ingredient within the chocolate standards (Code of Federal Regulation, 1973). O'Connell (1974) has indicated that candy manufacturers have been concerned about using whey in chocolate because of lactose intolerance, off-flavor, and alteration in mouth feel. However, with present day's improved knowledge of lactose hydrolysis and quality control, none of these considerations need remain a barrier to the acceptance of whey solids in confections.

New technology and economical methods to fractionate whey, such as electrodialysis, ultrafiltration, and age permeation have led to the manufacture of a variety of dehydrated whey protein concentrates with protein contents ranging from 29 to 90%. Electrodialyzed products are of particular interest to the chocolate manufacturer. Electro dialysis demineralizes the whey without removing any of the protein or lactose. Ultrafiltration and gel permeation, used either singly or in tandem, have the effect of separating the protein from the lactose and salts of the whey.

Table 5. Composition of Whey Protein Concentrates Prepared by Different Processes

Sample	Protein %	Lactose %	Ash %
A[a]	29	50.0	8.5
B[a]	35	55.0	3.0
C[b]	55	25.6	10.0
D[b]	72.8	7.2	13.8
E[b]	87.0	4.0	0.2

[a]Prepared by electrodialysis.
[b]Prepared by ultrafiltration and gel permeation.

Table 5 lists the composition of some commercially prepared whey protein concentrates. Products A and B have been demineraiized; product B is very close in composition to nonfat dry milk. The other products have been subjected to ultrafiltration followed by gel permeation in order to concentrate the protein.

O'Connell (1974) has demonstrated that a 25% demineralized whey could be successfully used as a sucrose replacer in a basic milk chocolate formula when substituted for 13% of the batch weight. In addition, the sucrose replacement permitted a reduction of the quantity of chocolate liquor required from 12.5% to 10% of the batch weight. Research is continuing to determine if whey or whey protein concentrate makes an adequate substitute for milk solids in chocolate.

In conclusion, a broader spectrum of whey products than ever before is now available. With the development of new confection formulations to take advantage of the unique properties of these products, whey should find a firm place as an ingredient in candy manufacture.

REFERENCES

Alikonis, J. J. 1972. Whey solids increasing use in confections. Proceedings of the Whey Products Conference, Chicago, June 14-15. ERRL Publ. #3779.

Cameron, A. T. 1947. The taste sense and the relative sweetness of sugars and other sweet substances. Report #9, Sugar Research Foundation, Inc. New York.

Cerbulis, J., J. H. Woychik, and M. V. Wondolowski. 1072. Composition of commercial wheys. J. Agric. Food Chem. 20 (5):1057.

Guy, E. J. 1974. Private Communication.

Guy, E. J., A. Tamsma, A. Kontson, and V. H. Holsinger 1974. Lactase-treated milk provides base to develop products for lactose-intolerant populations. Food Prod. Dev. 8 (8):50.

Holsinger, V. H. and E. J. Guy. 1084. Products from lactase-treated milk and whey. Proceedings of the Whey Products Conference. Chicago, Ill. Sept. 18-19. ERRC Publ. #3996.

International Critical Tables. 1927. Vol. II, 1st ed. p. 344-351.

Code of Federal Regulations. 1073 Cacao Products Title 21, part 14.

Kinsella, J. E. 1970. Functional chemistry of milk products in candy and chocolate manufacture Mfg. Conf. 50 (10):45.

O'Connell, R. T. 1974. Whey in Chocolates Confections. Proceedings of the Whey Products Conference, Chicago, Sept. 18-19. ERRC Publ. #3996.

Ramsdell, G. A. and B. H. Webb. 1938. Sweetened condensed whey: its manufacture and properties J. Dairy Sci. 21:305.

Thompson, M. P. and D. P. Brower. 1974 a. Manufacture of cheddar cheese from hydrolyzed lactose milks. J. Dairy Sci. 57:598.

Thompson, M. P. and D. M. Gyuricsek. 1974 b. Manufacture of yogurt, buttermilk, and cottage cheese from hydrolyzed lactose milks. J. Dairy Sci. 57:584.

Webb, B. H. 1966. Whey—a low-cost dairy product for use in candy. J. Dairy Sci. 49:1310.

Webb, B. H., A. H. Johnson, and J. A. Alford. 1974. Fundamentals of Dairy Chemistry. Avi Publishing Co. Westport, Conn. p. 300.

Whittier, E. O. and B. H. Webb. 1950. Byproducts from Milk. Reinhold Publishing Corp. New York pp. 225-237.

Reference to brand or firm name does not constitute endorsement by the U.S. Department of Agriculture over others of a similar nature not mentioned.

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